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Extraction of gypsum from plant and its role in agriculture industry

Budhsen Dubey [1] , Pawan Kumar Thimmaraja [2]

Student, doctor of philosophy P.K. University,shivpuri [1]

Professor,P.K.university,shivpuri [2]

Abstract: - I hope that with the help of this paper, Farmer will increase his farming method and crop fertility. Process of flue gas desulfurization and use of gypsum, then production of the flue gas produces by the thermal power plant, by the desulfurization process we can control pollution and find out gypsum. Finally, use of gypsum in many areas and increases productivity and revolution in farming by this process of gypsum.

Keywords:-FGD process, Farming process, pollution control, use gypsum in agriculture.

Introduction: -

It's been a long time since calcium sulphate is known as gypsum which is being used as a tool of multiple use in agriculture, around the globe. Its full availability, relatively lower price makes it an excellent agronomic and environmental tool to improve the soil physical and chemical properties. Basically, as it is being seen, even today it is very important to make the farmers aware about the new technology and the techniques to make the crop fertile. The initiative of the Government of India is moving towards the farmers. Information about new farming techniques is being made available to farmers by the Government of India through newspapers, TV news, journals, conferences and by going from village to village. Gypsum is a very soft mineral that is easily identified by its hardness, cleavage, and solubility in water. Typically clear to white, gypsum may be coloured reddish to brown or yellow if impurities are present. We know that today many thermal power plants are currently running in Madhya Pradesh, 6315 thermal plants are installed and by thermal power plant more flue gases are produced in the burning of coal than generation of electricity.

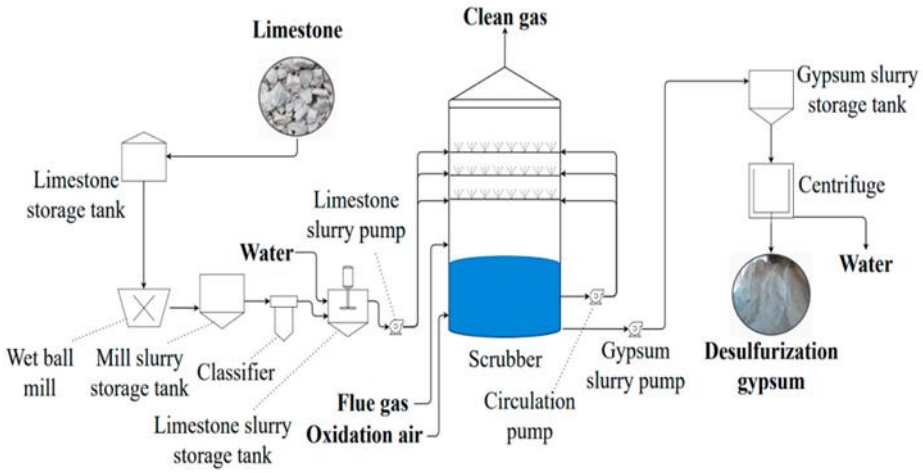
The English word for plaster is “Gypsum”, and German is “Gyps”. It all comes from the Greek (gypsos), and then the Latin word is “gypsus”. At that time, it didn’t mean gypsum in the modern sense, but meant something like moonstone.Gypsum is a moderately soluble source of the essential plant nutrients, calcium and sulfur, and can improve overall plant growth.The main components of gypsum are calcium sulfate ($CaSO_4$) and water (H_2O). Its chemical name is Calcium Sulphate Dihydrate and the chemical formula of gypsum is represented as $CaSO_4.2H_2O$. Gypsum and Anhydrite ($CaSO_4$) are very similar chemically just that gypsum has 2 water molecules and Anhydrite does not contain any water molecules.

Chemical Classification	Sulfate
Chemical Composition	Hydrous Calcium Sulfate, $CaSO_4.2H_2O$
Mohs Hardness	2
Specific Gravity	2.2
Colour	Colourless, Red, Brown, Clear, Yellow, White, Grey
Diaphanous Property	Transparent to translucent
Texture	Silky, Sugary, Vitreous
Cleavage	Perfect
Crystal System	Monoclinic
Diagnostic Properties	Specific gravity, cleavage, low hardness

Generally, the production process of gypsum powder is mainly divided into five stages first crushing second Screening third grinding fourth calcination and final storage and transportation. Raw gypsum ore is processed into a variety of products such as a Portland cement additive, soil conditioner, industrial and building plaster, and gypsum wallboard.

Working process of FGD

Flue gas desulfurization is the process of removing sulphur compounds from the exhaust emissions of fossil-fueled power stations. This is done through the addition of absorbents, which can remove up to 95% of the sulphur dioxide from the flue gas. For the removal of SO_2 from flue gas, a wet process using calcium carbonate as an absorbent is most commonly adopted in commercial plants. The wet process shows a high efficiency but needs a large amount of water. SO_2 is fixed in the form of calcium sulfate. One effective desulfurizer is a calcium-silicon alloy containing 30 percent calcium. Metallic calcium desulfurizes by forming the very stable compound calcium sulfide (CaS), and it is alloyed with silicon because pure calcium reacts instantaneously with water and is therefore difficult to handle.



Plant Layout for FGD process for Gypsum

`FGD Gypsum generation scenario in India The production of gypsum ($CaSO_4.2H_2O$) based on SO_2 removal can be estimated from the above chemical equation considering their molecular weights, 1 mole of SO_2 produces 1 mole of gypsum. The SO_2 emissions in the flue gas depends on the sulphur content of the coal burned. Considering the sulphur content of Indian coal to be around 0.35% and considering variation in specific coal consumptions of various unit sizes, Central electricity Authority (CEA) has estimated the FGD gypsum generation in tonnes per annum (tpa) per MW considering plant utilization or plant load factor (PLF) of 80% and 55% which is tabulated below:

Unit Capacity (MW)	Specific Coal Consumption (kg/kWh)	FGD gypsum generation	
		TPA/MW @80% PLF	TPA/MW @55% PLF
Upto 250	0.764	100.7	69.25
250-500	0.684	90.18	62
500-600	0.584	76.99	52.93
Abobe 600	0.524	69.08	47.49

Till December 2022, only the following 02 Coal Fired thermal power plants have installed Flue gas desulfurization (FGD) system:

Types of gypsum products: -

Type I – Impression Plaster

Type II – Dental plaster used in model material

Type III – Dental stone used in mounting material

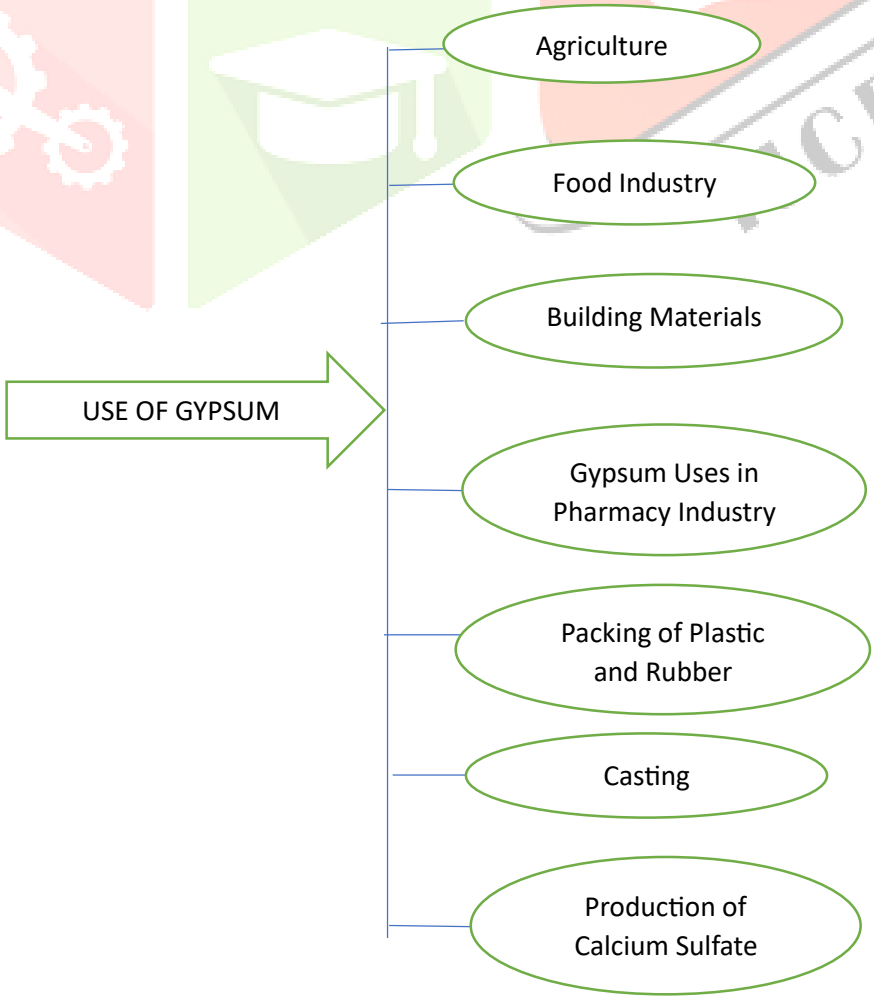
Type IV – Die stone or high storage stone

Type V – High strength which is used when a high expansion is needed as die material like in fabricating base metal alloy castings

Agricultural gypsum benefit

1. Improving soil structure helps farmers.
2. Provides Calcium and Sulphur.
3. Improves Crop Yield.
4. Reduces Crusting.
5. Improves Water Infiltration.
6. Reduces Compaction.
7. Reduces erosion by increasing the ability of soil to soak up water after precipitation, thus reducing run off proves Soil Structure.

Overview of the Gypsum (for gypsum processed and use)



Gypsum is a naturally occurring mineral that has been used by humans for various purposes for thousands of years. It is a versatile mineral with a wide range of applications in construction, agriculture, industry, and even art.

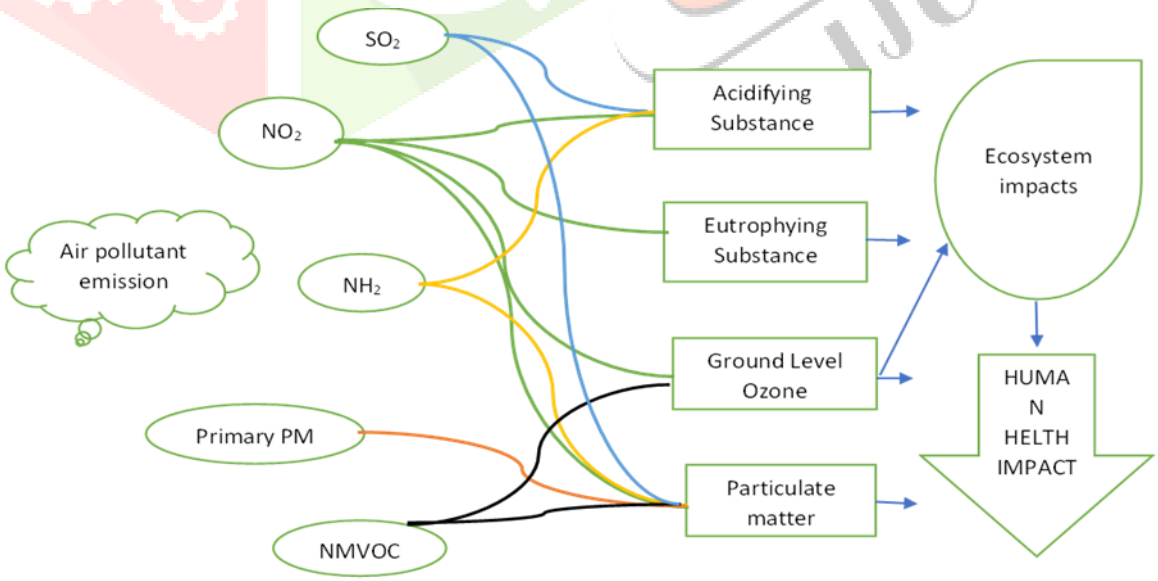
1.Agriculture: Gypsum is applied to soil in agriculture to improve its structure and reduce soil compaction. It provides essential calcium and sulphur nutrients to plants and can help in reclaiming saline or sodic soils.

2.Construction: Gypsum is widely used in construction as a building material. Plaster of Paris and gypsum board (drywall) are common products derived from gypsum. Plaster is used for creating decorative finishes on walls and ceilings, while gypsum board is used for interior wall and ceiling construction.

3.Industrial Applications: Gypsum has various industrial uses, including in the production of cement, as a filler in paper and textiles, and as a component in making Molds and casts. Art and Sculpture: Gypsum has a long history of use in art and sculpture. Artists use it to create intricate sculptures and Molds for casting. Gypsum is used to produce sulfuric acid, and then to produce ammonium sulfate fertilizer. Anhydrite can adjust the pH of the soil, improve the soil environment, and can also provide various fertilizers with nutrients such as calcium and sulfur. The application of calcium sulfate (gypsum) during peanut planting not only has a significant effect on increasing the yield of peanuts, but also plays an extremely important role in peanut pest control, efficient fertilization and soil improvement. Gypsum's chemical composition is relatively simple, consisting primarily of calcium, sulphur, oxygen, and hydrogen atoms. Its chemical formula, $CaSO4 \cdot 2H2O$, indicates that each unit of gypsum is composed of one calcium (Ca) atom, one sulphur (S) atom, four oxygen (O) atoms, and two water (H2O) molecules. The two water molecules are structurally bound to the calcium sulfate, giving gypsum its characteristic hydrated form.

4. The water content in gypsum is essential to its unique properties and versatility: -When gypsum is heated, it undergoes a process called calcination, during which it loses some or all of its water content, depending on the temperature and duration of heating. This results in the formation of different gypsum products with varying properties, such as plaster of Paris, stucco, and gypsum.

Emissions to Air and its Effects: -



FGD operation and production of FGD gypsum directly depends upon the coal consumption, Sulphur content in coal, quality of limestone etc. Therefore, the efficiency of FGD process may differ from unit to unit. The FGD operational parameters at different thermal power plants is as below:

S.No.	Parameters	Mahatma Gandhi TPP, Haryana	The Vindhyachal Thermal Power Station, M. P.	Udupi Power Plant, Karnataka
1	Sulphur in coal	. 0.35 %	10.49 %	0.53 %
2	Absorber Inlet SO2	1094 mg/Nm3	1852 mg/Nm3	2007.17 mg/Nm3
3	FGD Outlet SO2	108 mg/Nm3	178 mg/Nm3	984.96 mg/Nm3
4	Desulfurization Efficiency	90.1%	. 90.4 %	85%
5	Flue gas Inlet Temperature	125°C	145°C	140 ºC
6	Operating Condition	BMCR	BMCR	Wet condition (25% of the total flue gas)

Characteristics of Flue Gas Desulfurization (FGD) Gypsum

FGD Gypsum is a gray colored, fine grained powder having moisture content ranging 10-15%. The FGD gypsum contains 80-90% Calcium Sulphate Di-hydrate ($CaSO_4.2H_2O$) by mass and around 3% silica (as SiO_2). The range of oxides in FGD Gypsum depends highly on the quality of limestone used in the process. The characteristics of limestone and the FGD Gypsum generated from different thermal power plants is given below:

Limestone Characteristics

S.N.	Components	Mahatma Gandhi TPP, Haryana	Udupi Power Plant, Karnataka
1	**Size**	**10-80mm (>90%); Below 10mm (<10%)**	**50-60 mm**
2	**$CaCO_3$ (Calcium Carbonate)**	**> 90 %**	**80-98**
3	**CaO (Calcium oxide)**	**> 50.5 %**	**-**
4	**$MgCO_3$ (Magnesium Carbonate)**	**< 2.5 %**	**1.0-8.0**
5	**MgO (Magnesium oxide)**	**< 1.35 %**	**-**
6	**Silica (Si)**	**< 2.5 %**	**1.0-8.0**
7	**Fe_2O_3 (Iron(III) oxide or ferric oxide)**	**< 2 %**	**1.0-4.0**
8	**Al_2O_3 (Aluminum Oxide)**	**< 2 %**	**-**

Global Practices:

FGD system for removal of Sulphur from flue gas of Coal Fired Thermal Power Plant has been adopted globally decades ago. Thus, the FGD gypsum is being managed Globally through various methodologies. Globally, the following practices have been majorly adopted for utilization of FGD gypsum:

1. Production of Gypsum Board

2. Cement Manufacturing

3. Composite Binder

4. Soil Amendment

5. Mine Backfilling

Where is Gypsum Found?

Gigantic gypsums are formed beneath layers of sedimentary rock, along with halite, anhydrite, sulfur, calcite, and dolomite. Thick beds and layers of rocks are commonplace for finding gypsum. Ocean water is high in calcium and sulfate minerals so gypsum is also found in lagoons as the water in the ocean can slowly evaporate and be replenished with new sources of water. When water evaporates, the mineral is left behind. Evidence of gypsum dunes has been found on the planet Mars as well.

Physical and Chemical Properties of Gypsum Mineral

Gypsum was known as Spear Stone in old English since it takes a crystal-like form, projecting out of a rock like a spear. You can mix gypsum with water to get its original rock-like shape, and it can be hardened. Its recycling loop can be termed as a "closed recycling loop" since you can recycle it for a number of times and it never loses its quality. It is moderately soluble in water, and its solubility reduces with the rise in temperature, contrary to the behaviour of other salts. Here are some of its important chemical and physical properties at a glance:

Gypsum is heavily used as a building material, and in plaster of paris, as a matter of fact, about three-fourths of the total production is used for such purpose.

Utilization:

A significant number of studies and research projects have been undertaken globally as well as in India to find out beneficial utilizations of FGD Gypsum. The utilization of the FGD gypsum is directly proportional to its quality. The major parameters which affects the utilization potential of the FGD gypsum are Moisture, Purity for which Central Electricity Authority (CEA) in its "Standard Technical Specification for Retrofit of Wet Limestone Based Flue Gas Desulphurisation (FGD) System in a Typical 2x500 MW Thermal Power Plant" has outlined that "The system shall be capable of producing gypsum with residual moisture not more than 10 %, chloride content less than 100 ppm and purity not less than 90 % (depending upon purity of available limestone)". Further, in context of removing the impurities it has been stated that "The filter shall be designed with cake washing equipment. This equipment shall be capable of reducing the concentration of dissolved solids in the process liquor (primarily chloride) to levels that meet the commercial gypsum quality specifications."

Occurrence of Gypsum

As said earlier, Gypsum occurs along with other minerals such as halite and anhydrite. These all are the evaporite minerals, and hence the gypsum. It means that Gypsum is the sedimentary deposit, that is to say, it is deposited by the action or the work of wind or the water, usually in the bottom of the water body. In particular, Sulfate is deposited from the natural brine that occurs in the ocean, which is then followed by anhydrite and halite.

A Gypsum rock is first mined or quarried, the crushed and ground to a fine powder. It then goes through a process called calcining where heat at 350 degree is supplied to the gypsum powder which removes 3/4th of the water molecules. The raw materials of the gypsum powder is natural gypsum ore.

Throughout the world, gypsum deposits occur in many countries, but Spain, the United State of America, Russia, Turkey, and Thailand are the top-most producers of Gypsum. Since gypsum is dissolved in the water over a period of time, only on rare occasions it can be found in the form of sand, and hence mostly it is found in the crystal form. The gypsum crystal of more than 3 metres or of almost 10 feet in length, and of 0.4 metres or almost about 1.5 feet in diameter, was found in the Braden mine of Chile. This particular crystal of the Gypsum is one of the largest crystals of gypsum ever found.

CONCLUSIONS: -

This study involves desulphurization experiments in a spray dryer using relevant sorbents (hydrated lime, limestone and trona) to compare their performance characteristics towards the absorption of SO_2. This study focused on the utilization of waste from power plants, construction and demolition waste, agricultural wastes etc. The main conclusions are summarized as follows:

1. Concrete brick specimen S01 produced from 5.5% FGD gypsum without CDW and OPT cured at 28 days obtained the highest compressive strength (45.18 MPa), while concrete brick specimen S12 produced from 5.5% FGD gypsum, 75% CDW, and 1% OPT obtained the lowest compressive strength (26.84 MPa).

2. This technology can assist the farmers in the increased production and can help grow their business to a larger scale.

3. All established technologies can meet the demands for SO_2 removal for the Indian market

All technologies have different consideration and often related to operation and capital cost transferred to NPV

4.Specifically for low to medium range sulphur content, the DFGD and SWFGD will most probably be the preferred total evaluated technologies.

5. Adding only FGD gypsum in the production of concrete brick specimens showed that the compressive strength of these specimens increased with significant differences when compared to the compressive strength of the control.

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